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# Canadian Airborne Microwave Radiometer Platform for SMAP Science Applications and Cal/Val

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**Environment Canada**

*First Canadian Workshop on SMAP  
Applications and Cal-Val*

*October 6-7, 2009 Montreal*



# Climate Research Division – Research Activities

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**Mandate:** research activities to advance understanding of the climate system

- explain past and current state/behaviour and to predict/simulate future state

**Research Activities:**

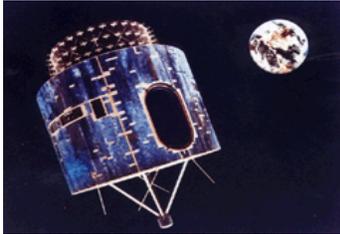
- Global and regional climate model development and evaluation → ‘Earth System’ model with a broad range of physical and biogeochemical processes
- Quantitative climate change projections for IPCC, national policy- and decision-making, and impact assessment
- Climate change detection and attribution
- Development of high quality climate data sets → trends, variability and extremes
- State, variability and change in the cryosphere → development of satellite retrieval methodologies
- Development of Canadian Land Surface Scheme (CLASS)
- Response of energy, water and carbon cycles within the boreal forest to climate variability and change
- Long term measurements and analyses of greenhouse gases, aerosols and stable isotopes



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# CRD Remote Sensing Research

**Derived information/products used to generate new knowledge on cold climate processes, cryosphere/climate interactions and support model development and assessment:**

- regional snow cover (SWE)
- lake ice freeze-up/break-up, and thickness
- large scale sea ice dynamics (e.g., sea ice motion)
- regional sea ice trends and extremes
- land and water surface temperature
- surface soil moisture

*Cryospheric variability and change*

*Boundary conditions for models*

*Climate model validation*

*Environmental monitoring/prediction*



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# EC-NRC Aircraft Facility

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- Environment Canada (EC) and the Flight Research Laboratory of the National Research Council of Canada (NRC) jointly developed an Environmental Research Aircraft Facility for conducting airborne research studies that address atmospheric, meteorological and climate science issues.
- Aircraft: Convair 580 (cloud physics and air quality research), Twin Otter (climate and air quality research)
- MOU between 2 agencies → MSC provides \$400K per year to support maintenance of facility and have access to aircraft for 6 months/year
- Projects pay for flying hours (preferred rates), fuel, NRC staff travel costs and overtime
  - Twin Otter flying costs: ~\$2000/hr (project, transit) plus fuel
- EC has staff dedicated to Aircraft Facility (manager, technicians) – projects pay for staff travel and overtime costs
- Cost of a 2 week aircraft/field campaign in western Canada is ~\$200K



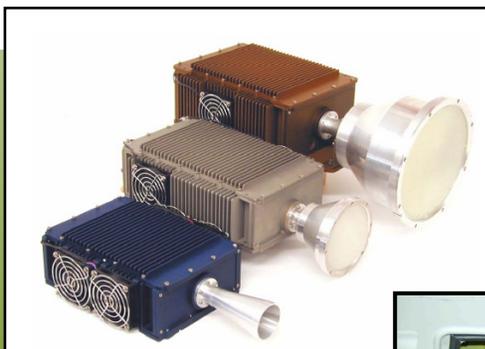
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# EC Microwave Radiometers

- microwave radiometers for meteorological, climate and sea ice research acquired beginning in 1995
  - 1995: 19, 37 and 85 GHz (to match SSM/I)
  - 2000: 1.4 and 6.9 GHz (to match AMSR-E and future L-band satellite mission)
  - 2003/04: replacement high frequency radiometers with 19, 37 and 89 GHz
  - 2007: replacement of 1.4 GHz (with RFI mitigation capability)



**Radiometer specifications**

	1.4 GHz	6.9 GHz	19.35 GHz	37 GHz	89 GHz
Beamwidth	30°	9°	6°	6°	6°
Polarization	Dual	Dual (H & V separate antenna)	Dual	Dual	Dual

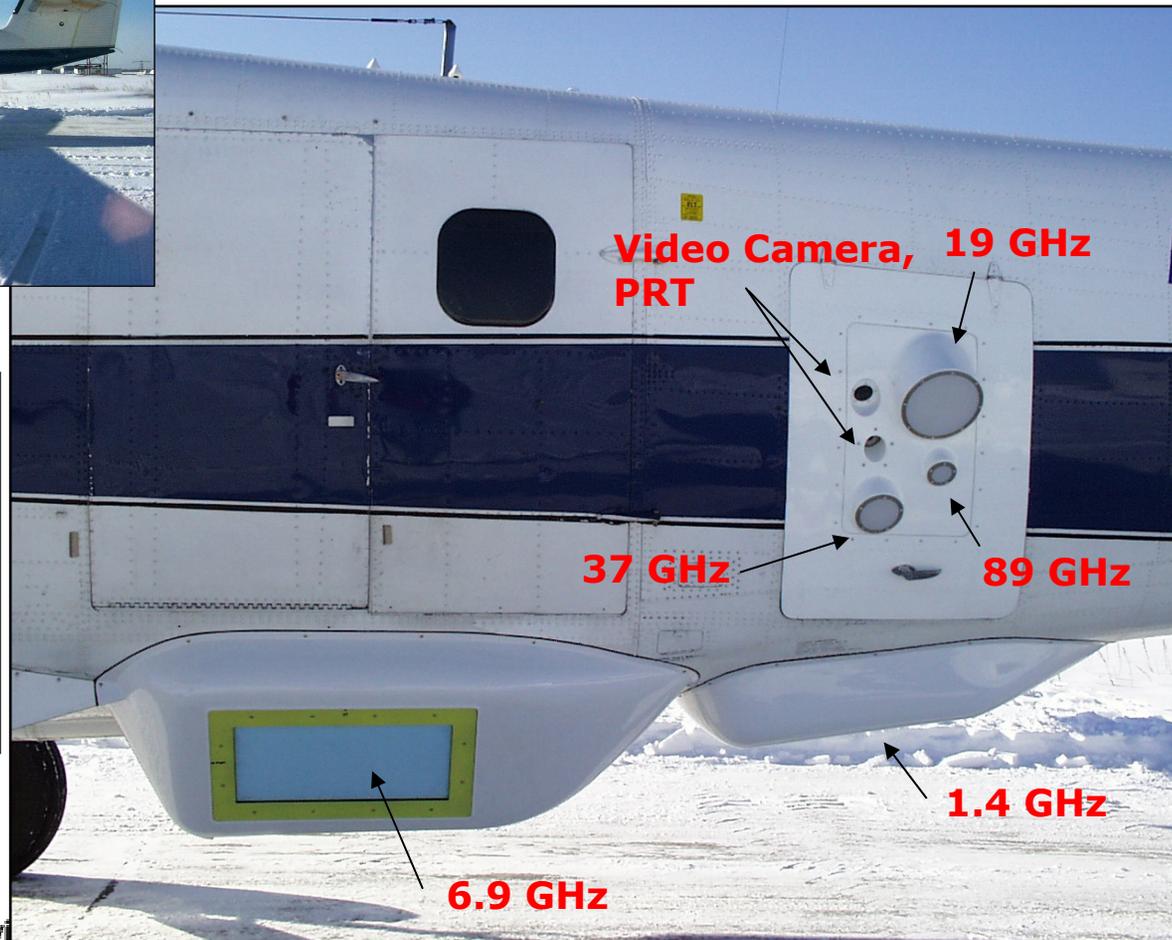


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# EC Microwave Radiometer Installation on NRC Twin Otter



- 6.9, 19, 37 and 89 GHz mounted at 53° incidence angle
- 1.4 mounted on belly with 5° incidence angle



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# Microwave Radiometer Calibration

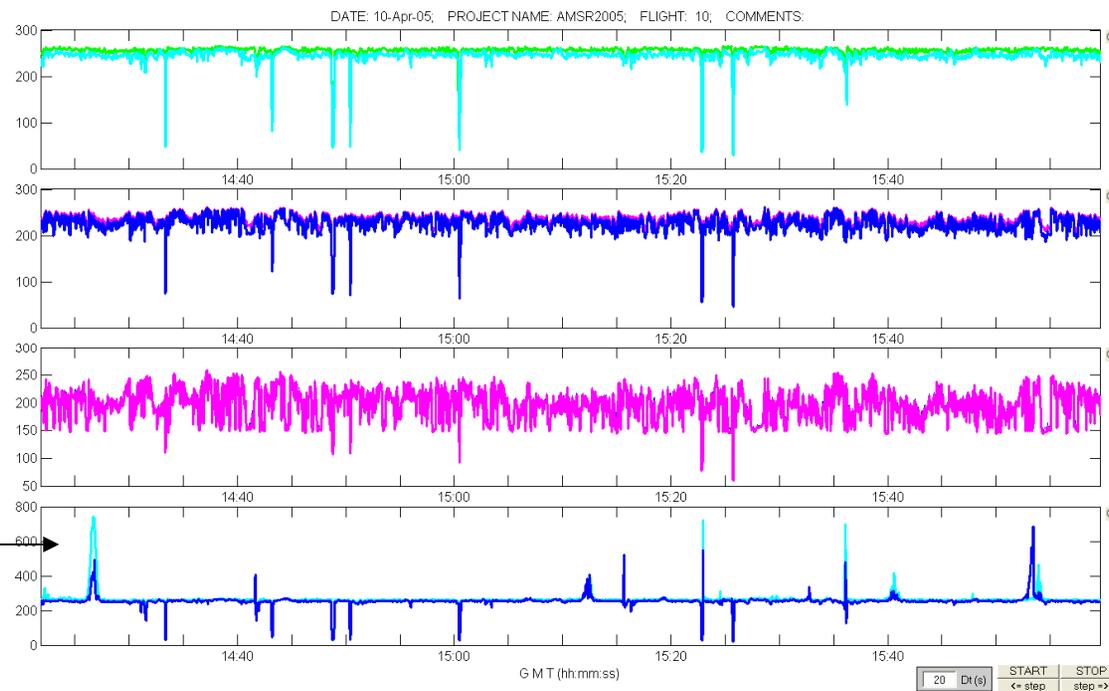
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- calibrations conducted before and after each flight
- Cold points: sky, liquid nitrogen; Warm point: echosorb at ambient temperature
- 1.4 and 6.9 GHz calibrations have been problematic due to effects of RFI, and antenna characteristics



# Radio Frequency Interference – 1.4 and 6.9 GHz

- Impact of RFI has been significant
  - affects calibration and scientific reliability of data acquired during flight
- 6.9 GHz RFI detected along flight lines near cities (cell phone transmission)
- 1.4 GHz RFI detected airports (air surveillance systems) and sign. impacts on calibration



6.9 GHz TB  
spikes up to  
400-600K

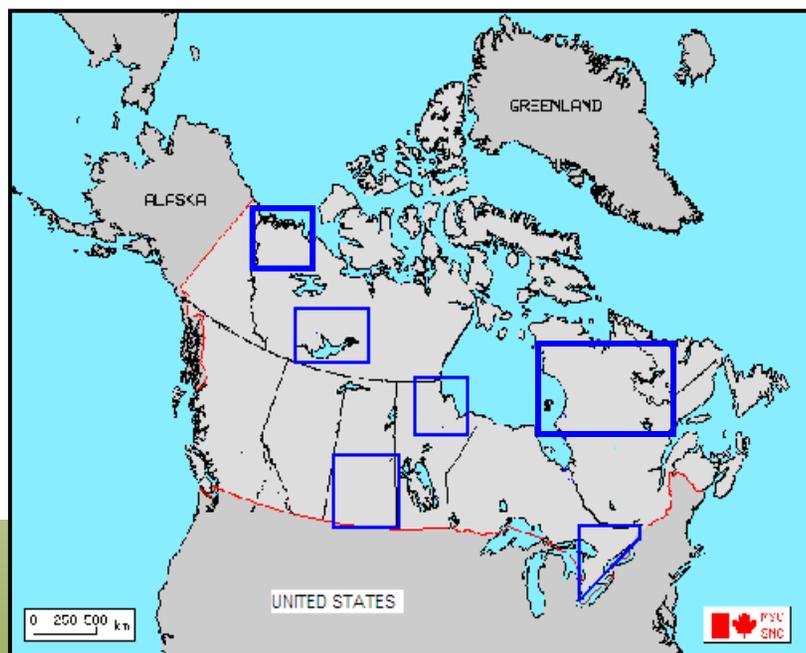


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# EC Airborne Microwave Radiometer Field Campaigns



Coincident *in situ*  
measurements



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- 1996-1999 – Seasonal Variations in Snowpack Emission (Eastern Ontario)
- 1997 – MERMOZ-97 (Eastern Ontario)
  - soil moisture measurements in support of boundary layer experiment
- 1999 – Synergism between Active and Passive Microwave Measurements for Snowpack Characteristics (Eastern Ontario)
- 2000 – Grand River Basin snow cover
- 2001 – Southern Ontario Soil Moisture Experiment
  - Sensitivity of high frequency microwave radiometers to varying soil moisture conditions
- 2003 – Validation of AMSR-E Snow Cover (prairies, boreal forest)
- 2005 – Tundra snow cover and lake ice (Northwest Territories)
- 2006 – Northern boreal forest, sea ice (Northern Manitoba)
- 2008 – IPY Snow Cover Campaigns (N. Quebec, NWT)

# Ground-based Microwave Radiometer Platform for Field Studies (SBR System)



- Developed by Canadian Ice Service to support Arctic sea ice field and ship-based investigations
- Recent upgrades include new sled-based deployment system for tundra landscape
- Winter 2009/10 deployment in Churchill, Manitoba for CoRe-H2O Phase A Science field investigation



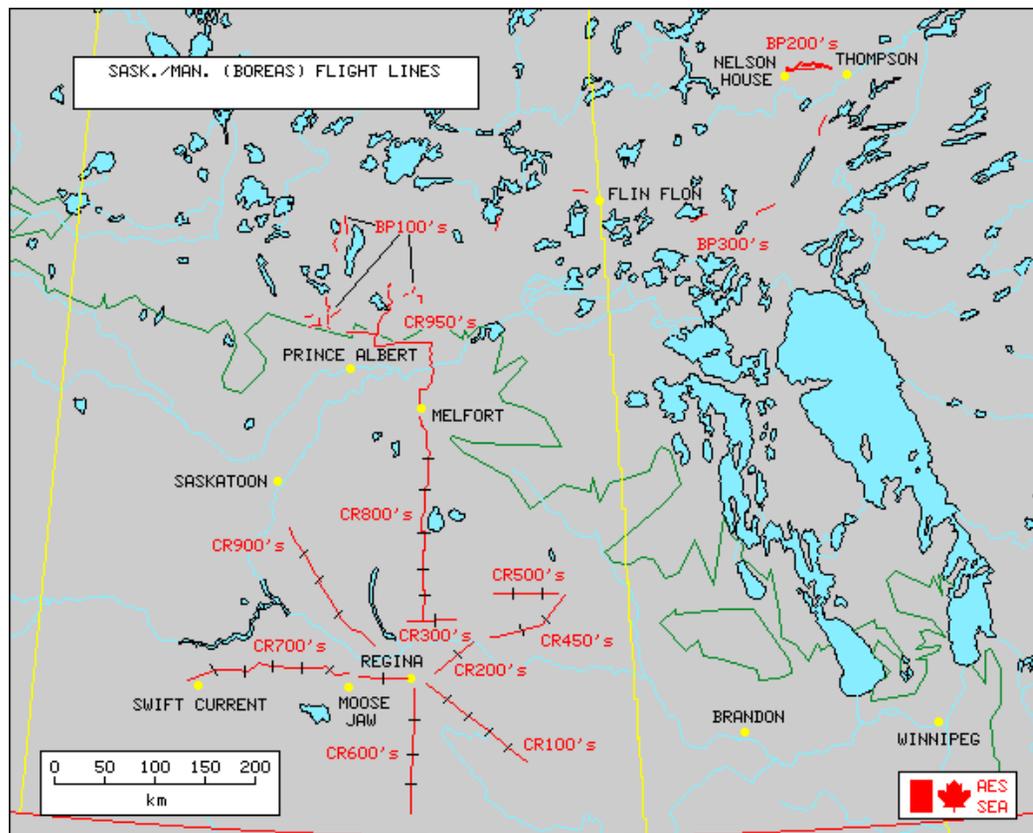
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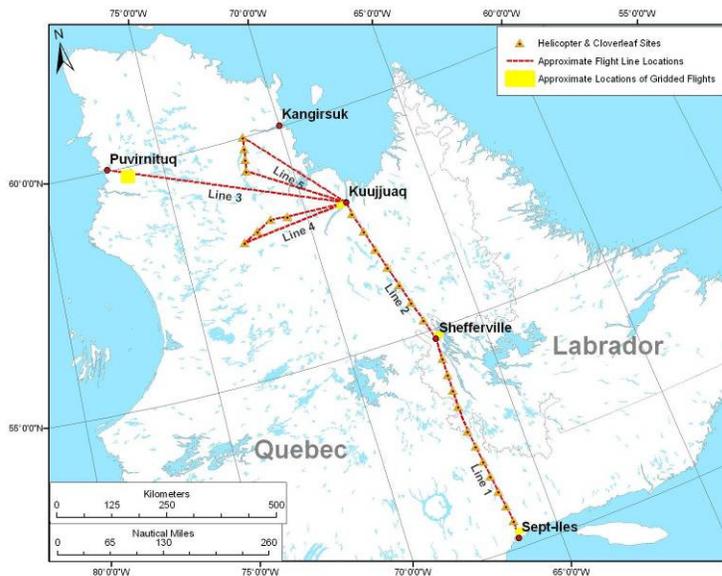
# Flight Line Networks – Western Canada

- Extensive flight line network established across agricultural region in southern Saskatchewan
- 20 years experience with airborne campaigns and field data collection in support of passive microwave snow cover research

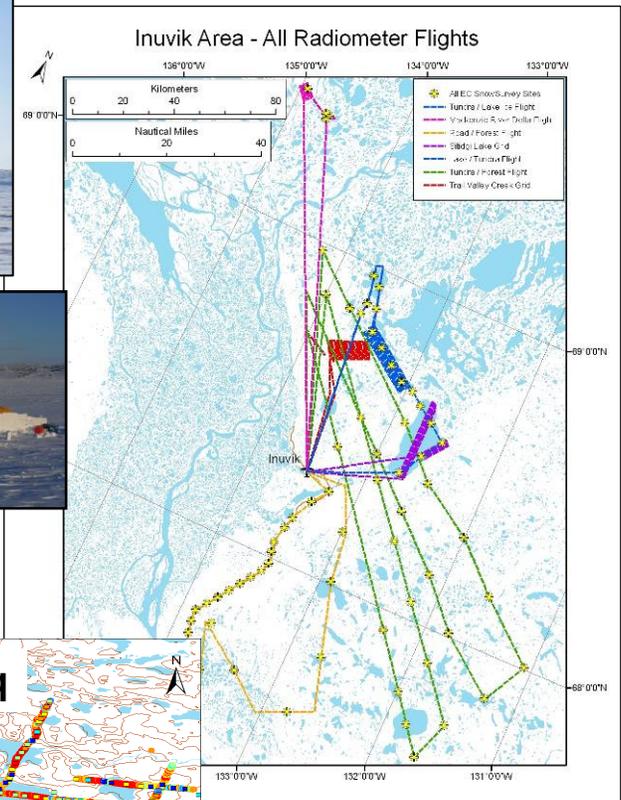


# International Polar Year Aircraft Remote Sensing Campaigns – Snow Cover and Lake Ice

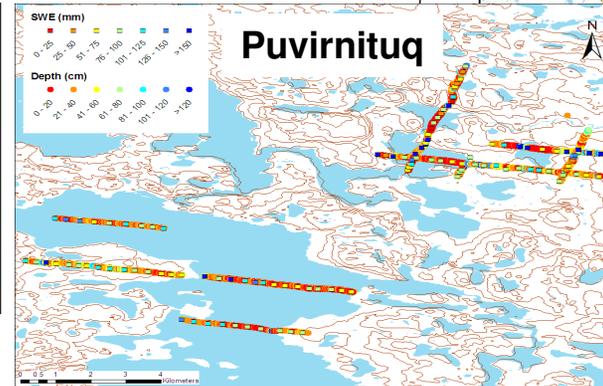
February 2008 – N. Quebec



April 2008 – NWT (Inuvik)



Airborne microwave radiometer data sets acquired to investigate landscape controls on microwave emission from snow cover in northern regions.



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# Measurement Approach



# Potential CRD Science Contributions to SMAP (follow-on from HYDROS commitments)

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- **conduct passive microwave airborne and conventional in-situ campaigns to develop and validate soil moisture and freeze/thaw products in Canadian regions**
  - **SMOS Validation Campaign in S. Saskatchewan – June 2010**
- **contribute airborne/tower-based microwave data sets for pre-flight algorithm development and testing**
- **Contribution of measurements from existing research field sites**
  - **BERMS – Boreal Ecosystem Research and Monitoring Sites (flux towers, meteorological measurements incl. soil moisture)**
  - **Bratt's Lake (S. Saskatchewan) – precipitation measurement network and other meteorological measurements**
- **investigate the spatial extent of soil freezing/thawing and the link to water, energy and carbon cycles through remote sensing, process studies (BERMS), and modelling (CLASS) - link with cryosphere research**
- **will ultimately lead to improvements in the LSAT component (e.g. CLASS) of regional and global climate models, which require representative parameterizations of land surface variables and processes**
- **proposed research requires partnering with other agencies and universities**



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